

**UTILIZATION OF *HYDRILLA VERTICILLATA* BY WINTERING WATERFOWL ON
THE TIDAL POTOMAC RIVER**

by

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ABSTRACT

Submersed aquatic vegetation (SAV) communities in the tidal Potomac River were decimated during the 20th century by multiple environmental and anthropogenic factors. With the major declines of SAV communities, waterfowl populations have declined greatly as well (Hindman 1989). *Hydrilla verticillata*, an introduced submersed aquatic plant, was first discovered in the tidal Potomac River in 1982 (Steward et al. 1984). One hundred nine waterfowl were collected from the tidal Potomac River and its tributaries during the 2007-2008 Virginian and Maryland waterfowl hunting seasons. The esophagi and gizzards were dissected and analyzed to determine the utilization of *H. verticillata* by wintering waterfowl. Only 2 duck species, Mallard (*Anas platyrhynchos*) and Lesser Scaup (*Aythya affinis*), consumed small amounts of *H. verticillata*, 2.52% and 0.20% aggregate percentage of esophageal content, respectively. An inverse relationship between *H. verticillata* and gastropod consumption was observed as the season progressed.

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INTRODUCTION

Alien species can wreak havoc on an ecosystem, especially if natural predators are absent. *Hydrilla verticillata*, a species of introduced submerged aquatic vegetation (SAV) originally native to Asia, has been introduced to the tidal Potomac River, spreading dramatically. Although natural consumers of *H. verticillata* such as *Hydrellia pakistanae*, *Hydrellia balciunasi*, and *Bagous hydrillae* (Balciunas, et al. 2002) are not present in the tidal Potomac River, *H. verticillata* may provide a food source for waterfowl to supplement the sparse native aquatic plant population that declined in 1960's and 1970's (Carter and Rybicki 1986). Compared to the breeding ecology of waterfowl, little research has been conducted on the wintering habits of waterfowl. Food habits studies of wintering waterfowl provide insight to the available and preferred foods of these avifauna.

Until 1930, SAV was prevalent in the tidal Potomac River including species such as wild celery (*Vallisneria americana*), coontail (*Ceratophyllum demersum*), naiad (*Najas* spp.), American water weed (*Elodea canadensis*), and curly pondweed (*Potamogeton crispus*) covering all but the deep channels of the River (Orth and Moore 1984). Beginning in the 1960's, SAV was decimated in the tidal Potomac River by multiple natural and anthropogenic impacts such as hurricanes, increased erosion and sedimentation, increased nutrient inputs from point sources such as wastewater treatment facilities, and non-point sources like agricultural runoff and atmospheric deposition. A 1978-1981 survey of the upper tidal Potomac River from Fort Belvoir, Virginia, to Washington, D.C., revealed that nearly all SAV communities had disappeared in the upper tidal Potomac River (Carter and Rybicki 1986).

H. verticillata first invaded the United States with its discovery in Florida in 1960 (Langeland 1996). In 1982, *H. verticillata* was discovered in the tidal Potomac River near Washington, D.C. (Steward et al. 1984), facilitating a resurgence of SAV (Carter and Rybicki 1986, Rybicki and Landwehr 2007). After the accidental introduction of *H. verticillata* to the tidal Potomac River, the SAV population increased dramatically. According to annual data collected by the Virginia Institute of Marine Science SAV Mapping Lab (VIMS 2005), no SAV beds were documented in the tidal Potomac River in 1978. Data were not collected from 1979 to 1983. However, in 1984, after the introduction of *H. verticillata*, the areal coverage of both exotic and native SAV in the tidal Potomac River increased to 475 ha (VIMS 2005), further increasing to 1,814 ha by 2005 (VIMS 2007). Rybicki and Landwehr (2007) found that although *H. verticillata* was the dominant SAV species, it did not displace the native SAV species; rather, SAV species diversity increased.

Erwin (1996) concluded that the *H. verticillata* communities in the tidal Potomac River improved water quality and provided a food source for waterfowl. Wintering waterfowl populations are positively correlated with SAV abundance in the tidal Potomac River, which has been dominated by *H. verticillata* since 1982 (Rybicki and Landwehr 2007).

The importance of *H. verticillata* to waterfowl was first recognized in 1977 when waterfowl abundance declined after removal of *H. verticillata* from a lake in Florida (Johnson and Montalbano 1987). When aerial coverage of *H. verticillata* and local waterfowl numbers were analyzed on 2 Florida lakes, the number of Lesser Scaup (*Aythya affinis*) increased as the aerial coverage of *H. verticillata* increased (Baca and Dolan 1991). *H. verticillata* has previously been identified as a food source for waterfowl. The plant itself provides a direct and

indirect (e.g., the benthic macroinvertebrates associated with *H. verticillata*) food source for waterfowl (Johnson and Montalbano 1989, Perry and Deller 1996). In Georgia, *H. verticillata* communities were found to support the highest density of macroinvertebrates and the number of macroinvertebrates was positively correlated with the surface area of *H. verticillata* (Peets et al. 1994).

While the Potomac River has historically been a frequent destination for wintering waterfowl, little research has been conducted to determine the feeding habits of these waterfowl wintering on the tidal Potomac River. On the contrary, multiple studies have been made of the food habits of wintering waterfowl on the Chesapeake Bay (Perry and Uhler 1988, Hindman 1989, Stewart 1962) and the Atlantic coasts (Martin and Uhler 1951). Perry and Uhler (1988) found that some waterfowl have altered their diet focusing on animal matter as a primary food source with the decline and change in SAV dominance in the Chesapeake Bay. These studies were conducted before *H. verticillata* became established in the tidal freshwater tributaries of the Chesapeake Bay and are therefore dated. Thus, an up-to-date food habits analysis of wintering waterfowl is necessary to determine the effects of this invasive aquatic plant on the local waterfowl feeding ecology. A study determining the utilization of *H. verticillata* by waterfowl on the Potomac River was conducted in the early 1980's, but a very small sample (11 birds) was studied and pen raised birds were used to observe feeding (Folker 1987). While this study concludes that waterfowl on the tidal Potomac River consume *H. verticillata*, it does not determine the feeding habits of the wintering waterfowl, including the variability of SAV consumption, food preference, and nutritional implications. A more in-depth study with a greater sample size, a wild waterfowl population, and larger study area is necessary to determine

the feeding habits of wintering waterfowl on the tidal Potomac River, to compare findings to those from the Chesapeake Bay, and to update a database based on a study conducted 20 years ago. Food habits studies of wintering waterfowl are important for wildlife and ecosystem managers to adequately assess the carrying capacity and aquatic-vegetative health of an ecosystem such as the tidal Potomac River for wintering waterfowl. Food habits data also tell us if waterfowl are generalists or if they seek out specific food items.

The objective, then, of this study was to determine to what extent the wintering waterfowl on the tidal Potomac River utilize *H. verticillata*. While this study was limited to 5 locations along the tidal Potomac River and its tributaries, it provides up-to-date data on the local food habits of wintering waterfowl. The following null hypotheses are addressed:

- 1) Wintering waterfowl on the tidal Potomac River do not consume *H. verticillata*.
- 2) *H. verticillata* does not provide a significant food source for waterfowl wintering on the tidal Potomac River.
- 3) *H. verticillata* consumption does not increase throughout the winter (November through January).
- 4) Diving ducks do not consume more vegetative matter (*H. verticillata*) than animal matter.
- 5) Puddle ducks consume the same amounts of *H. verticillata* as do diving ducks.

STUDY AREA DESCRIPTION

The Potomac River is the second largest tributary (36,055 km²) of the Chesapeake Bay (Schubel and Pritchard 1987) and is considered a scaled-down model of the Chesapeake Bay due to the similar salinity regimes and environmental attributes (Jonas 2007 pers. comm.).

The study area consists of 5 different locations along the tidal Potomac River and its tributaries from the Occoquan River to Quantico Creek, Virginia. This portion of the Potomac River contains freshwater (<0.5 parts per thousand salinity) and is tidally influenced. Due to Virginia and Maryland waterfowl hunting regulations, only 5 sampling sites were utilized in the study area (Figure 1).

- Location 1 (Fairfax County, Virginia) is a beaver impoundment with emergent marsh surrounded by mature hardwood trees and is located in a tributary of the Occoquan River.
- Location 2 (Fairfax County, Virginia) is in a stationary blind approximately 180 meters south of Location 1 in an emergent marsh with multiple tidal creek channels.
- Location 3 (Fairfax County, Virginia) is an open-water area along the Occoquan River with an average depth of 0.9 to 1.8 meters.
- Location 4 (Prince William County, Virginia) is a tidal freshwater emergent marsh along the northwestern portion of Occoquan Bay. The average water depth is 0.3 to 1 meter.
- Location 5 (Charles County, Maryland) is an open water area approximately 1.6 kilometers north of the mouth of Quantico Creek on the Potomac River with an average depth of 1.5 to 2.1 meters. Although Location 5 is along the Virginia shoreline; the water below the mean low –tide elevation is part of Maryland.

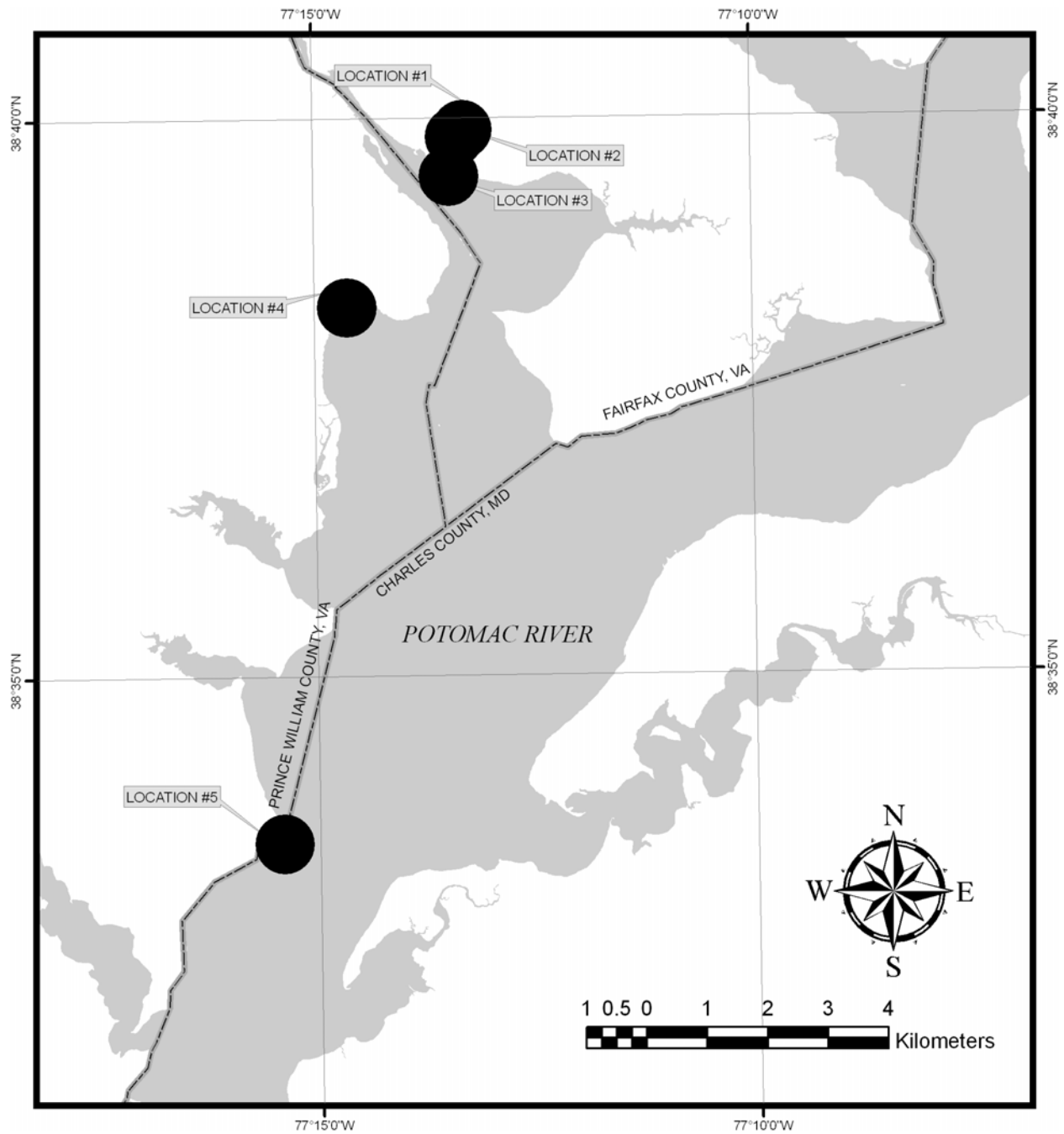


Figure 1. Location of the sampling sites along the tidal Potomac River. The shaded black circles represent the sampling areas. Although Location 5 is along the Virginia shoreline, the water below the mean low –tide elevation is part of Maryland.

METHODS

Field Collection: Waterfowl were collected using 12-gauge shotguns during the 2007-2008 Virginia and Maryland waterfowl hunting seasons during 12 different days. Depending on the sampling site used, the hunters were concealed on the shore in natural vegetation (Location 1), in a stationary blind (Location 2), or in a floating blind (Locations 3, 4, and 5). Locations 1, 2, and 4 were situated in emergent marsh areas that are associated with puddle ducks (Genus *Anas*), thus puddle duck and goose decoys were utilized to attract waterfowl to the locations. Locations 3 and 5 are open water areas along the Occoquan and Potomac rivers, respectively, and are associated with diving ducks (Genus *Aythya*). Diving duck and goose decoys were placed in these areas to attract waterfowl. Collection was conducted by 2 to 4 hunters per sampling date. All but 1 sampling period began at a half hour before sunrise (allowed by state regulation and in the interest of collection consistency to minimize any collection bias). Each sampling period was not limited to a certain time frame; however, the majority of sampling was completed before 1200 hours EST. Sampling periods ended at different times for different reasons (i.e., change of weather, limit of waterfowl collected, lack of waterfowl, etc.), and sometimes different locations were sampled in the same day due to the same previous reasons.

Prior to collecting specimens, birds' species and sex were identified. Ages (i.e., juveniles or adults) were not determined due to a lack of time and insufficient training in age determination. Immediately after collection, the esophagi of the waterfowl were injected with 12 cc of 90% isopropyl alcohol to prevent any post-mortem digestion. The species, sex, collection time, and assigned identification number of each bird were recorded in a field book as each bird

was retrieved. The identification number for each bird consisted of the date and the order in which the bird was collected (e.g., 12.28.07.3 – this bird was the 3rd bird collected on 28 December 2007). The identification number assigned to each bird was written on blue-glo flagging tape with permanent marker and tied to the foot of the bird for later identification after transport to the laboratory. Weather conditions (i.e., temperature, wind direction, tide, and cloud cover) were also recorded.

Laboratory analysis: At the end of each sampling hunt, the birds were transported in a cooler to this author's house to be processed. Before processing, each bird was weighed (g) and the overall length of the bird (tip of bill to end of longest tail feather) was measured (cm) and recorded in the field book. The esophagus and gizzard of each bird were removed and placed in 90% isopropyl alcohol in zip-lock freezer bags. Each bag was labeled with the associated bird identification number and stored in the freezer until each was able to be dissected.

The gullet and gizzards were dissected and the contents measured separately due to digestive rates bias. Because the gizzard is designed to macerate the food content before entering the small intestine (Pettingill 1961), softer-bodied contents such as leaves and some animal matter are quickly broken down and are not identifiable in the gizzard content. The unmacerated hard-bodied food matter still remains, which would increase the percentage of the content composed of hard-bodied food items if only the gizzard were analyzed (Briggs et al. 1985, Swanson and Bartonek 1970). A 10 X ocular microscope was used to verify the *H. verticillata* plant material if too small to be identified by the naked eye. The Maryland Department of Natural Resources (2008) *Bay Grass Identification Key* was used to determine if vegetative matter was *H. verticillata*. The *H. verticillata* content and total gullet and gizzard

contents were measured volumetrically in a 10 mL graduated cylinder to the nearest 0.1 mL, both the volume of the *H. verticillata* and the volume of total gullet and gizzard contents measured separately. During the dissection process, I noticed that aquatic snails (Order Gastropoda) were common in the gullets and gizzards, so I also began to measure the gastropod content to the nearest 0.1 mL. All food contents were preserved in 90% isopropyl alcohol and stored in shell vials. A label with the identification number was inserted into each vial. The volumes of the gullet and gizzard contents were recorded on pre-printed data sheets and entered onto an Excel spreadsheet.

Data Analysis: As described by Baldassare and Bolen (2006), the frequency of occurrence, aggregate volume, and aggregate percentage of *H. verticillata* and gastropod content of the esophagi, gizzards, and combined content were calculated. Because the gastropod content was not measured for all birds collected, there were varying sample sizes (N values) utilized for the calculations. The frequency of occurrence is calculated by dividing the number of birds in the sample with the specified food content by the total number of birds in the sample, then multiplying by 100 to provide a percent value. The aggregate volume was calculated by dividing the total amount of the specified content in the sample by the total content amount of the sample, then multiplying by 100. The aggregate volume method has associated biases; it allows the aggregate volume of food content to be exaggerated when one sample consumes a large volume of a certain food item, which inflates the overall aggregate volume of that food item. Because this method was used for the majority of food-habit studies prior to 1975 (Baldassare and Bolen 2006), it was utilized to compare the current results to past studies. The aggregate percentage method derives a percent volume of the specified item in each bird and then averages each

percent volume over the entire sample. The aggregate percentage method removes the bias associated with aggregate volume by giving equal weight to each bird in the sample and is the most commonly used analysis of food habits performed today (Baldassare and Bolen, 2006).

In Excel, I performed regression analysis using ordinary least squares with various combinations of explanatory variables and computed t-statistics to determine significance (Gotelli and Ellison 2004). This analysis was primarily performed on species of ducks with a sample size $N > 25$ primarily for purposes of maintaining a high degree of statistical power. However, all data, including small samples, were analyzed to determine if other relationships were evident.

RESULTS AND DISCUSSION

Ducks were collected on 12 different days during the 2007-2008 Virginia and Maryland waterfowl hunting seasons from November 17, 2007 to January 19, 2008. We collected 116 ducks, but 7 were omitted due to specimen damage. Of the 109 samples analyzed, 6 different duck species were represented, including Mallard (*Anas platyrhynchos*; N=57), Lesser Scaup (N=34), Ring-necked Duck (*Aythya collaris*; N=7), Canvasback (*Aythya valisineria*; N=6), Ruddy Duck (*Oxyura jamaicensis*; N=3), and Bufflehead (*Bucephala albeola*; N=2).

H. verticillata Content - All Ducks

Of all the intact ducks collected (N=109), the aggregate volume of *H. verticillata* in the esophagi, gizzards, and combined volume was 0.82%, 2.57%, and 1.65%, respectively. The aggregate percentage of *H. verticillata* in the esophagi, gizzards, and combined volume was 1.38%, 5.57%, and 5.60%, respectively. The frequency of occurrence of *H. verticillata* in the esophagi, gizzards, and combined volume was 4.59%, 13.76%, and 14.68%, respectively (Table 1). However, *H. verticillata* was only consumed by two species, the Mallard and Lesser Scaup.

H. verticillata Content – Mallards

The Mallards (N=57) had an aggregate volume of *H. verticillata* in the esophagi, gizzards, and combined volume of 4.82%, 5.14%, and 5.05%, respectively. The aggregate percentage of *H. verticillata* in the esophagi, gizzards, and combined volume was 2.52%, 7.88%,

Table 1: The aggregate volume, aggregate percentage, and frequency of occurrence of *H. verticillata* consumed by waterfowl (N=109) in the study area (after Baldassare and Bolen 2006).

	Esophagi	Gizzards	Combined
Aggregate Volume (%)	0.82	2.57	1.65
Aggregate Percentage (%)	1.38	5.57	5.60
Freq. of Occurrence (%)	4.59	13.76	14.68

Table 2: The aggregate volume, aggregate percentage, and frequency of occurrence of *H. verticillata* consumed by Mallards (N=57) in the study area (after Baldassare and Bolen 2006).

	Esophagi	Gizzards	Combined
Aggregate Volume (%)	4.82	5.14	5.05
Aggregate Percentage (%)	2.52	7.88	7.84
Freq. of Occurrence (%)	5.26	15.79	15.79

and 7.84%, respectively. The frequency of occurrence of *H. verticillata* consumed by Mallards in the esophagi, gizzards, and combined volume was 5.26%, 15.79%, and 15.79%, respectively (Table 2). These results differ greatly from that of Montalbano et al. (1979), who found *H. verticillata* to be the most common food item in Mallards in Florida. This difference may be due to the longer growing season and milder winters in Florida in which the *H. verticillata* is available longer into the winter before it senesces. Furthermore, the increased growing season may allow the *H. verticillata* tubers to be larger and contain more nutrients, thus more desired by the waterfowl. The *H. verticillata* tubers found in the esophagi and gizzards of these study Mallards were small, <10 mm long. To better understand the differences between this study and that of Montalbano et al. (1979), a complete food habit's study and habitat assessment would be necessary to determine if this difference is a function of preference, availability, or other factors not addressed by the current research.

H. verticillata Content - Lesser Scaup

The Lesser Scaup (N=34) had an aggregate volume of *H. verticillata* in the esophagi, gizzards, and combined volume of 1.54%, 1.62%, and 1.60%, respectively. The aggregate percentage of *H. verticillata* in the esophagi, gizzards, and combined volume was 0.20%, 4.66%, and 4.80%, respectively. The frequency of occurrence of *H. verticillata* consumed by Lesser Scaup in the esophagi, gizzards, and combined volume was 5.88%, 17.65%, and 20.59%, respectively (Table 3). Although Lesser Scaup had a higher frequency of occurrence of *H. verticillata* than Mallards, the percent in their diet was less, therefore rejecting the null

Table 3: The aggregate volume, aggregate percentage, and frequency of occurrence of *H. verticillata* consumed by Lesser Scaup collected (N=34) in the study area is presented (after Baldassare and Bolen 2006).

	Esophagi	Gizzards	Combined
Aggregate Volume (%)	1.54	1.62	1.60
Aggregate Percentage (%)	0.20	4.66	4.80
Freq. of Occurrence (%)	5.88	17.65	20.59

hypothesis that puddle ducks (Mallards) consume the same amounts of *H. verticillata* as do diving ducks (Lesser Scaup; see statistical analysis beyond). However, the difference in consumption between the 2 species is rather small and these data only reflect consumption during the winter months when *H. verticillata* is senescing. When *H. verticillata* is senescing the leaf and stem matter has died off and only the tubers remain in the soil substrate. Because the only *H. verticillata* that is available is in the soil substrate, the waterfowl may not be consuming as much due to the decrease in availability.

The null hypothesis that wintering waterfowl do not consume *H. verticillata* was rejected (see statistical analysis beyond). However, the amount of *H. verticillata* consumed was less than 10% of the diet, thus failing to reject the null hypothesis that *H. verticillata* does not provide a significant food source for waterfowl wintering on the tidal Potomac River (see statistical analysis beyond). *H. verticillata* was not found in the Ring-necked Ducks, Canvasbacks, Ruddy Ducks, or Buffleheads collected. No relationship between *H. verticillata* consumption and species, sex, weight, month, or time of day was observed.

Gastropod Content - All Ducks

Because the gastropod content was not measured for all ducks collected, the sample size for gastropod content analysis was smaller (N=83). It should be noted that a bias between esophagus and gizzard content exists with food habits studies due to the digestion resistance of hard food items such as gastropod shells and seeds (Swanson and Bartonek 1970). The function of the esophagus is to store food prior to digestion in the gizzard. Once the food content reaches the gizzard, muscular action with the aid of grit grinds up the food content and soft-bodied foods

can be rapidly pulverized. The rapid digestion prevents the softer bodied food items, such as leaves and certain animal matter, from being recognized in the gizzard content, thus not identified in the food content. This may be the reason for an increase in gastropod content in the gizzards, due to their hard shells. However, the gizzard and combined content were still calculated to compare these results with past studies. Of the 83 ducks in this sample, the aggregate volume of gastropods in the esophagi, gizzards, and combined volume was 8.24%, 60.49%, and 30.74%, respectively. The aggregate percentage of gastropods in the esophagi, gizzards, and combined volume was 5.07%, 38.46%, and 38.36%, respectively. The frequency of occurrence of gastropods in the esophagi, gizzards, and combined volume was 8.43%, 44.58%, and 45.78%, respectively (Table 4). Martin and Uhler (1951) found that the aggregate volume of gastropods consumed by ducks along the Atlantic coast was 11.04%, which is approximately one third of the volume found in this study (30.74%). This increase in gastropod consumption suggests a dietary shift of waterfowl in the tidal Potomac River which would not be unrealistic given the date that the Martin and Uhler (1951) study was conducted when marshes and SAV beds were more prevalent and available as a food source. Gastropods were consumed by all species except the Ruddy Ducks and Buffleheads. Compared to *H. verticillata* content, gastropods were consumed at much higher levels.

Gastropod Content – Mallards

The Mallards (N=48) had an aggregate volume of gastropods in the esophagi, gizzards, and combined volume of 5.30%, 19.00%, and 14.90%, respectively. The aggregate percentage of gastropods in the esophagi, gizzards, and combined volume was 2.25%, 21.31%, and 18.53%,

Table 4: The aggregate volume, aggregate percentage, and frequency of occurrence of gastropods consumed by waterfowl (N=83) in the study area (after Baldassare and Bolen 2006).

	Esophagi	Gizzards	Combined
Aggregate Volume (%)	8.24	60.49	30.74
Aggregate Percentage (%)	5.07	38.46	38.36
Freq. of Occurrence (%)	8.43	44.58	45.78

respectively. The frequency of occurrence of gastropods consumed by mallards in the esophagi, gizzards, and combined volume was 4.17%, 27.08%, and 29.17%, respectively (Table 5).

Stewart (1962) found Mallards to have a 0% frequency of occurrence of gastropods in their total diet. Perhaps my results are a function of tidal wetland loss along the Potomac River and the increase in gastropod consumption is due to lack of vegetative food availability.

Content Comparison – Mallards

Considering the potential digestive bias, the esophagi contents of both *H. verticillata* and gastropods in Mallards are similar. Although availability of other data is not known, these results suggest that Mallards have no preference between *H. verticillata* and gastropods. This would suggest the need for additional study to validate this hypothesis.

Gastropod Content - Lesser Scaup

The Lesser Scaup (N=19) had an aggregate volume of gastropods in the esophagi, gizzards, and combined volume of 95.90%, 99.20%, and 98.60%, respectively. The aggregate percentage of gastropods in the esophagi, gizzards, and combined volume was 15.57%, 89.19%, and 89.07%, respectively. The frequency of occurrence of gastropods consumed by Lesser Scaup in the esophagi, gizzards, and combined volume was 15.79%, 89.47%, and 89.47%, respectively (Table 6). Regression analysis further supported the importance of gastropods in the diet of Lesser Scaup. For every unit of *H. verticillata* consumed by Lesser Scaup, 0.75 units of gastropods were consumed ($P < 0.01$). The frequency of occurrence (89.47%) of gastropods in Lesser Scaup total diet in this study is a slight increase compared to Stewart's (1962) findings

Table 5: The aggregate volume, aggregate percentage, and frequency of occurrence of gastropods consumed by mallards (N=48) in the study area (after Baldassare and Bolen 2006).

	Esophagi	Gizzards	Combined
Aggregate Volume (%)	5.30	19.00	14.90
Aggregate Percentage (%)	2.25	21.31	18.53
Freq. of Occurrence (%)	4.17	27.08	29.17

Table 6: The aggregate volume, aggregate percentage, and frequency of occurrence of gastropods consumed by Lesser Scaup collected (N=19) in the study area (after Baldassare and Bolen 2006).

	Esophagi	Gizzards	Combined
Aggregate Volume (%)	95.90	99.20	98.60
Aggregate Percentage (%)	15.57	89.19	89.07
Freq. of Occurrence (%)	15.79	89.47	89.47

(77%). On the contrary, the frequency of occurrence (15.79%) of gastropods in the esophagi decreased greatly compared to the Lesser Scaup collected in South Carolina (57.1%) (Hoppe et al. 1986). Furthermore, the Lesser Scaup in South Carolina had a higher aggregate percentage of gastropods in esophagi (19.9%) compared to the current study (15.57%). However, the differences between these samples are not that great and could be a function of random selection, availability, and preference. Future research should include benthic sampling to determine the availability of benthic macroinvertebrates to waterfowl, which would allow preference to be determined as well.

Content Comparison – Lesser Scaup

Regression analysis was used to compare the consumption of *H. verticillata* and gastropods by Lesser Scaup. For every unit of *H. verticillata* consumed by Lesser Scaup, 22.58 units of gastropods were consumed ($P < 0.01$). These findings reject the null hypothesis that diving ducks consumed equal amounts of *H. verticillata* and animal matter (i.e., that there was no difference in rates of consumption). The content of *H. verticillata* and gastropods in the esophagi of Mallard was similar, suggesting a similar preference. On the contrary, the esophagi content of Lesser Scaup consisted of more gastropods than *H. verticillata*. The amount of *H. verticillata* is a fraction of the gastropod content, suggesting that *H. verticillata* is consumed incidentally in this species.

Gastropod Content – Ring-necked Ducks

The gastropod content of the Ring-necked Ducks (N=6) included an aggregate volume of gastropods in the esophagi, gizzards, and combined volume was 16.67%, 82.14%, and 70.59%, respectively. The aggregate percentage of gastropods in the esophagi, gizzards, and combined volume was 2.78%, 78.59%, and 75.48%, respectively. The frequency of occurrence of gastropods consumed by Ring-necked Ducks in the esophagi, gizzards, and combined volume was 16.67%, 100%, and 100%, respectively (Table 7). Regression analysis was used to test and validate these findings. For every unit of food volume in the gizzard of Ring-necked Ducks, 0.91 units of gastropods were present ($P < 0.01$), indicating a high percentage of the Ring-necked Duck diet being composed of gastropods. This represents a sizable increase in gastropod consumption from Stewart's (1962) findings (35% frequency of occurrence) in Ring-necked Ducks. This increase may be, in part, due to the absence of pondweeds in the tidal Potomac River, which had a 53% frequency of occurrence in Ring-necked Ducks during this much earlier study (Stewart 1962).

Other Food Content - Canvasbacks

Of the Canvasbacks collected (N=6), only 2 had a measurable amount of food content in the esophagi and gizzards. These 2 ducks consumed 22.3 mL and 29.1 mL of wild celery (*Vallisneria americana*) tubers, which consisted of 100% of the esophagi content. The gizzards of these 2 specimens contained 2.7 mL and 0.1 mL of wild celery tubers. The remaining Canvasback samples (N=4) had no measurable food content in the esophagi or gizzards. The esophagus can expand and contain large amounts of food, unlike the gizzard (Manville 2008

Table 7: The aggregate volume, aggregate percentage, and frequency of occurrence of gastropods consumed by Ring-necked Ducks collected (N=6) in the study area is presented (after Baldassare and Bolen 2006).

	Esophagi	Gizzards	Combined
Aggregate Volume (%)	16.67	82.14	70.59
Aggregate Percentage (%)	2.78	78.59	75.48
Freq. of Occurrence (%)	16.67	100.00	100.00

pers. comm.). This physical characteristic further exemplifies the limited accuracy of gizzard content analysis as explained by Swanson (1970). Perry and Uhler (1982 and 1988) found Canvasbacks consumed virtually no submerged aquatic vegetation, rather the primary food consisted of Baltic clams (*Macoma balthica*), which indicated a dietary shift from the historically preferred wild celery. This shift was attributed to the decline in wild celery throughout the Chesapeake Bay Region. Although the sample size from this study (N=6) is small, wild celery was the dominant food item in the Canvasbacks collected. This observation suggests the tidal Potomac River contains enough wild celery for Canvasbacks to be able to return to their historically preferred food. Further study will help validate that hypothesis.

Seasonality

For the purpose of assessing seasonal consumption of *H. verticillata* and gastropods, only the 2 species that consumed *H. verticillata* (Mallards and Lesser Scaup) were analyzed. Mallards were collected each month of the waterfowl hunting season (November-January). The total amounts of *H. verticillata* consumed per Mallard in November, December, and January were 0.05 mL (N=8), 0.02 mL (N=39), and 0.02 mL (N=10), respectively (Figure 2). The decrease in consumption of *H. verticillata*, therefore, fails to reject the null hypothesis that *H. verticillata* consumption does not increase throughout winter (November to January). This decrease may be due to the senescence of the plant, which makes the tubers more difficult to locate, or a change in food preference.

Contrary to Mallard consumption of *H. verticillata*, the consumption of gastropods increased each month. Mallards consumed 0.00 mL/Mallard (N=3) of gastropods in November,

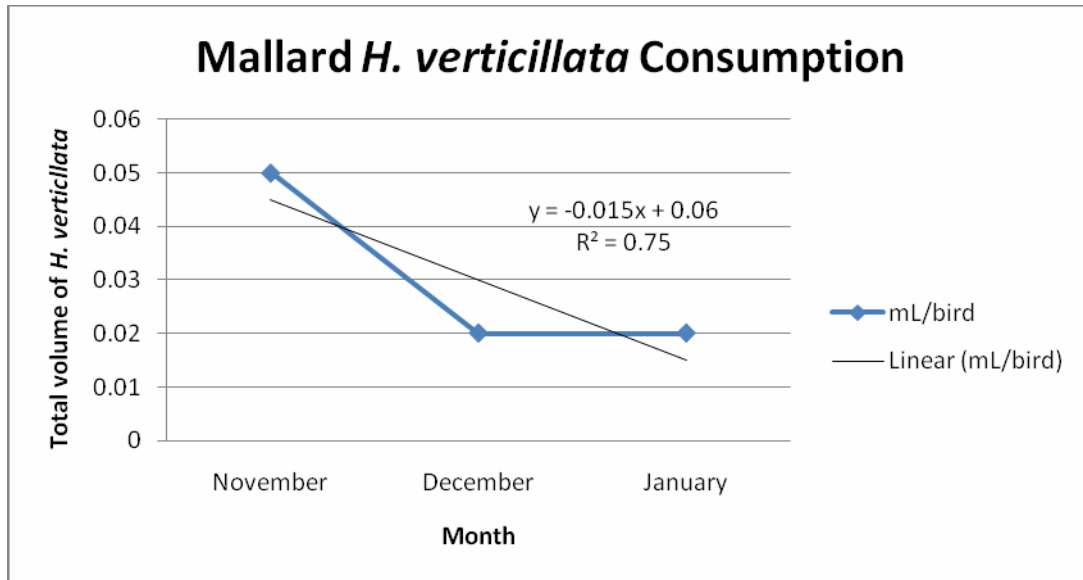


Figure 2. The total amount of *H. verticillata* consumed by Mallards from November 2007 to January 2008.

0.03 mL/Mallard (N=36) in December, and 0.29 mL/Mallard (N=9) in January (Figure 3).

Although only 10 Mallards were collected in January, they consumed 236% more gastropods than the 39 Mallards collected in December. As winter progressed the Mallard consumption of gastropods increased 0.20 mL/month ($P < 0.01$). The consumption of *H. verticillata* and gastropods by Mallards are inversely related, which suggests a seasonal dietary shift. Further research is necessary to determine the causes of this shift (e.g., plant senescence, food availability, food preference, changes in water temperature and chemistry, etc.).

Lesser Scaup were only collected in December and January. Lesser Scaup consumption of *H. verticillata* per bird decreased from December to January, 0.03 mL (N=23) and 0.00 mL (N=11), respectively (Figure 4).

Like Mallards, Lesser Scaup consumed more gastropods per bird as the season progressed. In December and January, 1.25 mL (N=11) and 1.84 mL (N=8), respectively, of gastropods were consumed (Figure 5). Although only 11 Lesser Scaup were collected in January, they consumed 168% more gastropods/Lesser Scaup than the 23 Lesser Scaup collected in December, indicating an increase in gastropod consumption as the season progressed. Wooten (2004) also found Lesser Scaup to increase gastropod consumption from early to late season.

H. verticillata senesces in late October leaving only the tubers available as a winter food source (Baca 1991). As Sherfy (1999) discussed, plants are available as food in early winter and then die off, but the benthic macroinvertebrates continue to be available. Due to these biological functions, one would expect a seasonal dietary shift from vegetative to animal food content. The results from this study seem to reinforce that conclusion.

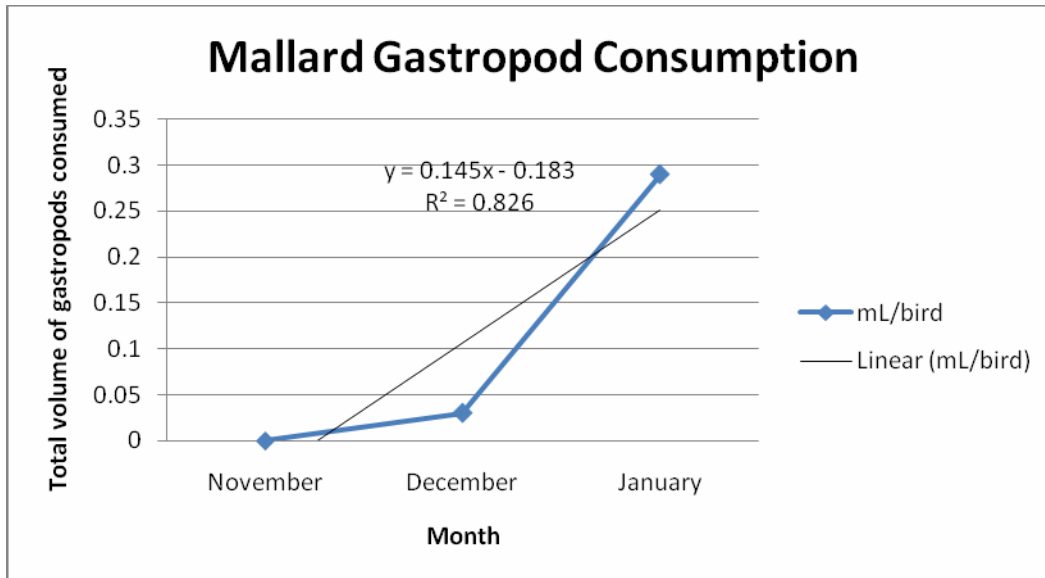


Figure 3. The total amount of gastropods consumed by Mallards from November 2007 to January 2008.

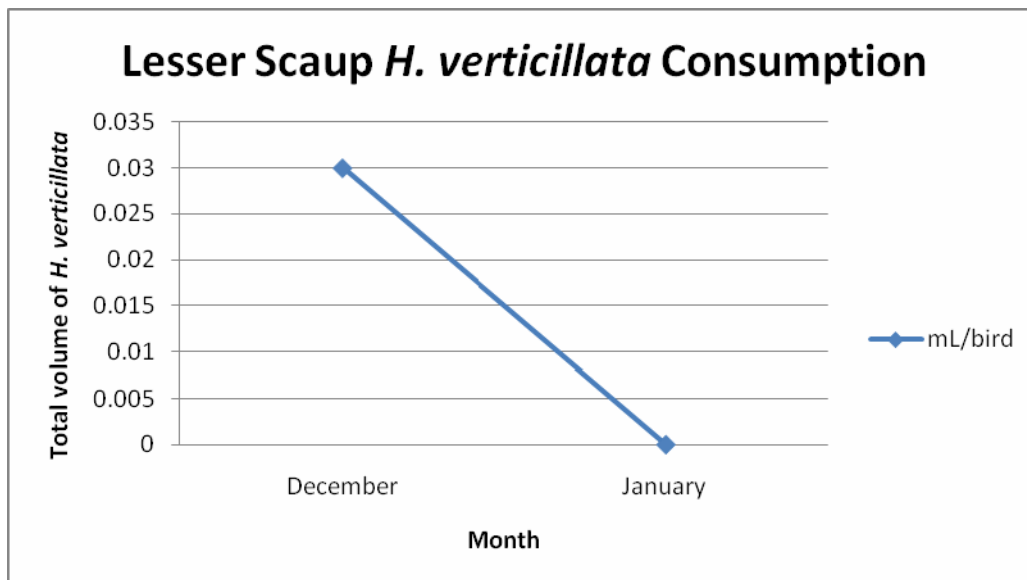


Figure 4. The total amount of *H. verticillata* consumed by Lesser Scaup over time, December 2007 to January 2008.

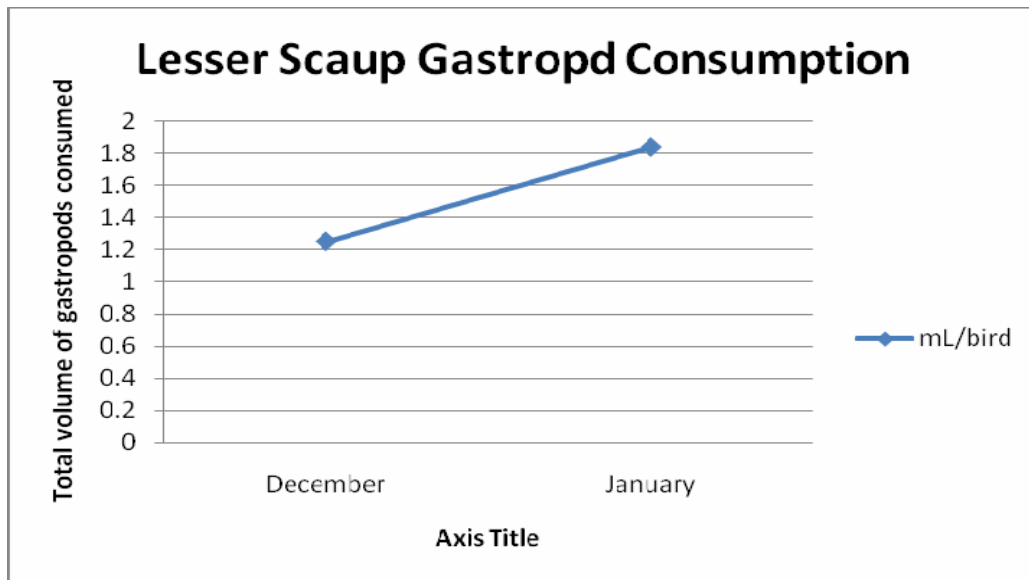


Figure 5. The total amount of gastropods consumed by Lesser Scaup over time, December 2007 to January 2008.

Consumption and Location

Total *H. verticillata* consumed by ducks at each sampling location per collection was determined to be 0.35 mL (N=2) at Location 1, 0.10 mL (N=4) at Location 2, 0.15 mL (N=4) at Location 3, 0.20 mL (N=2) at Location 4, and 0.10 mL (N=2) at Location 5. Location 2 showed the strongest positive relationship with the amount of *H. verticillata* in the gizzards ($P < 0.01$) of the entire sample (N=109). Locations 1, 2, and 4 are in shallow tidal freshwater wetlands and *H. verticillata* was not observed in these locations during the sampling periods. Because waterfowl are transient species, it is possible they fed on *H. verticillata* in different areas and were collected after feeding from areas where they had not fed. None of the waterfowl were observed actively feeding before being collected, which could explain the significantly lower volume of *H. verticillata* found in the esophagi (0.6 mL) versus the gizzards (1.7 mL) of the collected waterfowl.

The total amount of gastropods consumed by ducks at each sampling location per collection was determined to be 1.65 mL (N=2) at Location 1, 0.08 mL (N=4) at Location 2, 3.43 mL (N=4) at Location 3, 0.05 mL (N=2) at Location 4, and 8.65 mL (N=2) at Location 5. The largest amount of gastropods/collection occurred at Locations 3 and 5, which are deep water habitats where diving ducks (i.e., Lesser Scaup and Ring-necked Ducks) were collected.

CONCLUSIONS

The esophagi and gizzards of 109 waterfowl were collected from the tidal Potomac River and its tributaries during the 2007-2008 Virginian and Maryland fall/winter waterfowl hunting seasons. The *H. verticillata* and gastropod content of the esophagi and gizzards were analyzed. The results of this study indicate that *H. verticillata* is in fact utilized by wintering waterfowl on the tidal Potomac River. However, it was found in small amounts only in Mallards and Lesser Scaup, and did not constitute a significant portion of the diet. On the contrary, gastropods made up a large portion of the diet of Mallards, Lesser Scaup, and Ring-necked Ducks.

H. verticillata consumption in this study was lower than previous reports from Florida. The difference in growing season may produce larger and more nutrient-rich *H. verticillata* tubers in Florida, thus making it a preferred and more available food source there. In the tidal Potomac River, *H. verticillata* senesces earlier in the winter leaving only the small tubers as the available *H. verticillata* food source.

A dietary shift was noticed from November to January in the Mallards and Lesser Scaup. As winter progressed, *H. verticillata* consumption decreased as gastropod consumption increased. Future studies should be conducted for longer periods (i.e., from first fall arrival to spring migration). The expanded sampling period would provide a better understanding of seasonal variability in diet.

Wild celery was the dominant food consumed by Canvasbacks. In recent decades, Canvasbacks have shifted their diet from wild celery to Baltic clams due to the decline in wild

celery. These results suggest wild celery coverage in the tidal Potomac River is once again sufficient to support the wintering Canvasbacks and a dietary shift may be taking place.

Further studies are necessary to more adequately understand the utilization of *H. verticillata* and food habits of wintering waterfowl on the tidal Potomac River. Habitat assessments including SAV bed transects and benthic community evaluations would provide availability data that could, in turn, be interpreted to determine preference. Furthermore, regional variations may be too significant to compare waterfowl diets of different regions. In turn, the information from site-specific locations such as in this study may be helpful to the U.S. Fish and Wildlife Service that sets the seasons and bag limits for waterfowl nationwide, making recommendations to Maryland and Virginia through the Service Regulations Committee on those quotas. A better understanding of the science and dynamics of SAV, gastropod consumption, and related issues makes for better sustained yield management based on sound science and adaptive management applications.

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